Attentional bias to threat following acute stress induction: An ERP study

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I declare that this report is my own original work and that contributions of others have been duly acknowledged.

Signed: …… Date: ……

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Abstract

This study employed trauma-exposed and non-trauma-exposed individuals to explore group differences in physiological arousal, ERP components, and attentional bias to threat: a bias towards threatening stimuli often seen in individuals with posttraumatic stress disorder (PTSD). Attentional bias was assessed using reaction time measures in a dot-probe task and the amplitudes of ERP components P1, N1, and P3; while arousal was assessed using salivary alpha-amylase (sAA), a biomarker of noradrenergic reactivity. Eighteen trauma-exposed (non-PTSD) and 19 non-trauma-exposed individuals undertook the dot-probe task, with saliva tested before and after a cold pressor stress (CPS) task that was used to induce acute stress. The CPS task was successful in inducing acute stress and significantly increasing sAA in both groups, although no significant difference was found between the groups on physiological arousal. Unexpectedly, no significant attentional bias effect was found in the reaction time data for either group, in contrast to empirical literature. The major finding was that trauma-exposed individuals displayed increased amplitude of the P3 ERP component to threatening images following the CPS task, an effect not found in the non-trauma-exposed group. This finding suggests that trauma-exposed individuals show an attentional bias to threatening stimuli even in the absence of PTSD.

It is well-established that people with heightened anxiety levels exhibit an attentional bias to threat, which can be described as the preferential allocation of attention to threatening stimuli over neutral stimuli (Bar-Haim et al., 2007; Li, Li, & Luo, 2005). Attentional biases are highly maladaptive in the absence of actual threat, with research suggesting that these biases cause an inefficient processing style which wastes cognitive resources, thereby impacting important processes such as explicit memory retrieval (Naim et al., 2014). McHugh, Behar, Gutner, Geem, and Otto (2010) suggest that attentional bias to threat is a key mechanism in the development and continuation of anxiety disorders. Whilst attentional biases have been observed in individuals with posttraumatic stress disorder (PTSD: DePierro, D'Andrea, & Pole, 2013; Fani et al., 2012), few studies have examined the impact of trauma exposure more generally on attentional bias. There is growing evidence that trauma exposure can affect neural and threat processing (Karl, Malta, & Maercker, 2006; Stark et al., 2015; Zhang, Kong, Han, Hasan, & Chen, 2014) in people who have not developed PTSD following trauma exposure, but this has not been extensively examined in conjunction with attentional bias to threat. The aim of this thesis is to examine attentional biases towards threat in trauma-exposed and non-trauma-exposed individuals.

Effects of Trauma Exposure and PTSD

Exposure to trauma can take many forms, including active military service, being physically or sexually assaulted, involvement in a life-threatening accident, or witnessing another person be severely injured or killed. Such experiences can lead to post-traumatic stress disorder (PTSD) in approximately 10% of people (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995), but many people may present with some

symptoms of PTSD following trauma exposure without developing clinically-diagnosable PTSD (Zhang et al., 2014). While the overwhelming majority of research has examined the impact of PTSD, fewer studies have examined whether trauma-exposure itself has an impact on attentional bias, physiology, and neural processes. Imaging and ERP studies in recent years have returned increasing evidence that PTSD as well as trauma exposure alone can have significant effects on brain volume, neurotransmitter systems, and anatomical structures (Stark et al., 2015). An extensive meta-analysis of studies which utilised a traumatised population to investigate hypothesised differences in brain structures concluded that individuals who had been exposed to trauma but did not have PTSD showed decreased volume in both the left and right hippocampus compared to non-traumatised controls (Karl et al., 2006). Regarding functional differences in individuals with PTSD, fMRI was used to uncover diminished medial prefrontal cortex function as a biomarker of PTSD (Shang et al., 2014), whilst MRI has also been used to find decreased control of inhibition in parietal regions (Depue et al., 2014), however, imaging studies have neglected to examine those with trauma-exposure who have not developed PTSD (Zhang et al., 2014). Based upon PTSD imaging studies, it is possible that trauma exposure alone may cause significant changes in the brain structures and processes of affected individuals, in the presence or absence of PTSD or other anxiety disorders. Further to this, trauma history and exposure, rather than PTSD or dissociative symptoms, was found by Kimble, Fleming, and Bandy (2010) to predict abnormalities in the amplitude of P3 ERPs in a sample of 27 male military cadets using an auditory oddball task.

Theoretical Models of Attention Bias

A meta-analysis conducted by Bar-Haim and colleagues (2007) resulted in the development of a multistage model which describes the processes involved in attentional bias to threat, and is an advance on previous theories and models due to its integration of several processes into one simplified model (Cisler & Koster, 2010). The model, displayed below in *Figure 1*, suggests that anxious individuals may show maladaptive attentional processing at several different processing stages, accounting for attentional bias to threat.

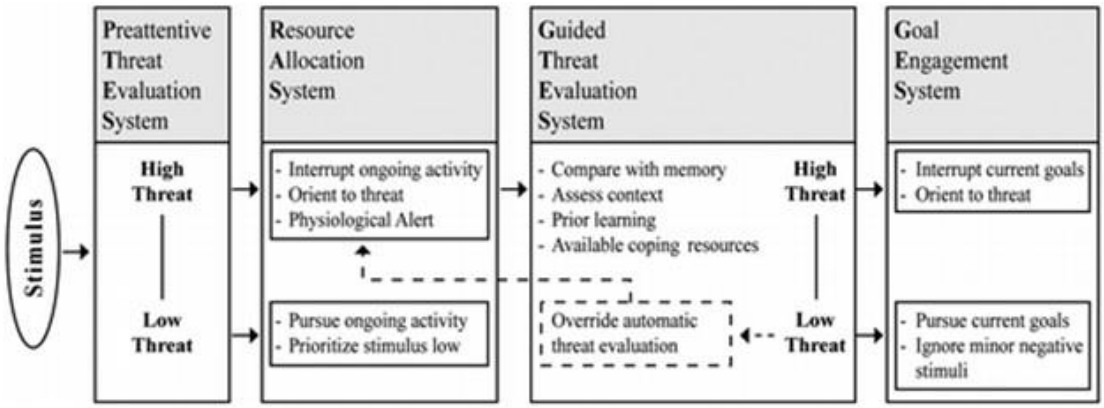

Figure 1. Model of Attention Bias developed by Bar-Haim and colleagues, 2007.

This integrative model has four distinct mechanisms: the preattentive threat evaluation system (PTES), the resource allocation system (RAS), the guided threat evaluation system (GTES), and the goal engagement system (GES) (Bar-Haim et al., 2007). The PTES is the initial step of the model, and is a key mechanism in attentional bias to threat in relation to the orientation of processing resources and activation of physiological arousal. The PTES is an unconscious attentional process which evaluates environmental stimuli, sending threatening stimuli to the RAS, which elicits both physiological arousal and the allocation of cognitive resources to the threatening stimuli (Carr, Scully, Webb,

& Felmingham, 2015). If the unconscious process of the RAS deems the threat as high in significance, attention will be maintained on the threat and a high state of anxiety will result (Bar-Haim et al., 2007). This anxious state is thought to be prolonged in people with an attentional bias to threat, which maintains anxiety levels as well as physiological arousal such as increased heart rate and stress hormones (Rohleder & Nater, 2009).

At this point, the conscious attentional processing of the GTES activates, assessing the strength, context, and relevance of the threat against prior experience, with an outcome of deeming the stimuli as low-threat or high-threat (Bar-Haim et al., 2007). In the low-threat outcome, the physiological arousal is consciously overridden by the GES and the low-threat stimuli is ignored, allowing functioning to return to normal (Carr et al., 2015). In the high-threat outcome, the physiological arousal is maintained while the GES consciously inhibits current task-oriented behaviours to focus attention on the threat, which has been compared to previous experiences or memory and found to be threatening in this context, and worthy of the orientation of the attentional processing systems (Bar-Haim et al., 2007).

As described in the Bar-Haim model (2007), physiological arousal is a key factor in attentional bias to threat, with such arousal including stress hormone release, increased heart rate, and minimisation of non-essential processes such as digestion (DePierro et al., 2013). Noradrenaline secretion is involved in preparing the body for imminent physical actions related to fighting or fleeing a threatening situation or stimulus. This fight or flight response is also characterised by negative cognitions, which include increased allocation of attention to threatening or frightening stimuli and the perception of ambiguous information or stimuli as negative (Jett & Morilak, 2013).

In individuals with a high level of anxiety, this perception is constant, leading to hypervigilance and an attentional bias towards information that appears to be threatening (Naim et al., 2014).

A central mechanism which modulates attentional bias (referred to as affect-biased attention by the authors) has been proposed by Markovic, Anderson, and Todd (2014) to be the increased activation of noradrenaline in the locus coeruleus. The locus coeruleus is a nucleus in the pons which is the primary site of noradrenaline production in the brain, and is heavily involved in triggering physiological responses to stress and fear (Carr et al., 2015). The increased activation of noradrenaline leads to changes in the visual cortex, causing an increase in the arousal experienced due to emotionally salient stimuli, which is generally negative when the individual is feeling stress or panic (Southwick et al., 1999). The Biased Attention via Norephinephrine (BANE) model merges genetic, behavioural, and neural components, all of which explain some of the variance in attentional bias (Markovic et al., 2014). The BANE model focuses on the noradrenergic processes in areas including the amygdala and orbitofrontal cortex; both of which are involved in directing attention to emotionally important stimuli and consolidation of memory (Markovic et al., 2014). Enhanced noradrenaline secretion is suggested to be implicated in stress-induced disorders such as PTSD (Southwick et al., 1999); and in regards to anxiously-responding individuals, the BANE model suggests there is an inability to employ executive control functions to ignore negative stimuli within the person's environment when physiological arousal is high (Todd, Cunningham, Anderson, & Thompson, 2012).

Dot-probe Tasks

The attentional processes which form the Bar-Haim model (Bar-Haim et al., 2007) can be tested using dot-probe tasks (MacLeod, Mathews, & Tata, 1986), which are considered to an accurate measure of attentional bias to threat as they measure the direction of the bias in terms of avoidance or fixation on the threatening image (Cisler & Koster, 2010; Fani et al., 2012). *Figure 2* shows an example dot-probe task below.

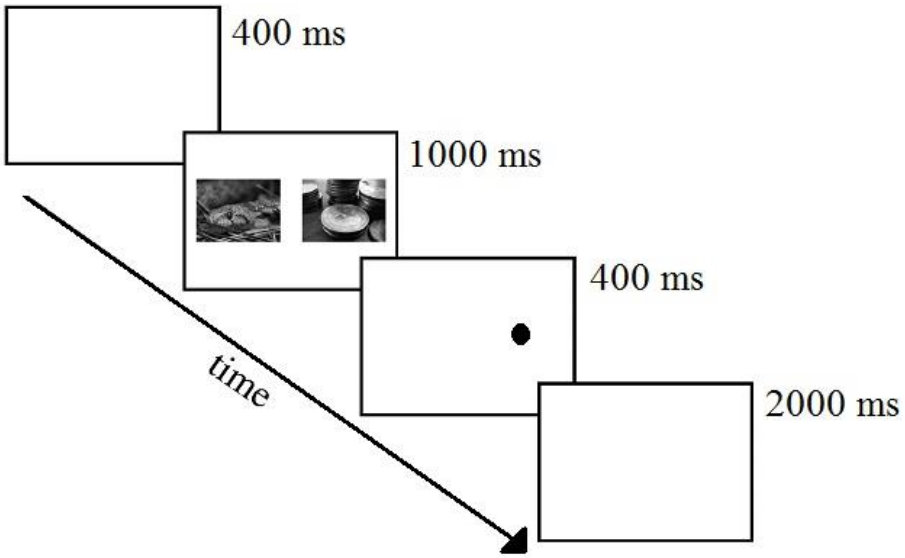

Figure 2. Example dot-probe task: A blank screen is presented before a pair of images, then followed by a blank screen with the dot-probe on the left or right. Time is given after offset of the probe to respond before the next trial begins. The 'time' bar shows the presentation time of each screen.

Dot-probe tasks are suggested to measure attentional bias in a more refined way than Stroop or lexical decision tasks as they do not require semantic processing, which can slow down reaction time (Fani et al., 2012). Dot-probe tasks are interpreted using reaction time (RT), with attentional bias suggested when individuals have a faster RT to congruent trials. Congruent trials involve a neutral and a threatening image displayed together, with a dot-probe appearing after offset of the images on the same side of the screen as the threatening image was previously located (Waechter, Nelson, Wright,

Hyatt, & Oakman, 2014). This faster RT is suggested to be due to the individual's attention being captured by the threatening image, leading to a faster response when the probe is on the same part of the screen (Carr et al., 2015). In many anxiety disorders, there is evidence of increased attentional bias to threat using dot-probe (for reviews, see Cisler & Koster, 2010; Pergamin-Hight, Naim, van Ijzendoorn, & Bar-Haim, 2014), however, studies testing populations with PTSD using a dot probe task have been limited, and those that have used this task have returned mixed results (Fani et al., 2012; Iacoviello et al., 2014). Many attentional bias studies using individuals with extensive trauma exposure or PTSD have neglected to use a control group (DePierro et al., 2013; Fani et al., 2012; Naim et al., 2014), meaning that while they provide important information about individuals with such disorders, conclusions cannot be drawn about differences between PTSD, trauma exposure, and non-clinical samples.

Attentional avoidance is suggested when a participant has a slower RT to the probe following a threatening image, with the assumption that attention is focused on the neutral image and the threatening image is avoided. Attentional avoidance is a key symptom of PTSD and is also found in individuals who have been exposed to trauma (Iacoviello et al., 2014); however, research by Elsesser, Sartory, and Tackenberg (2004) concluded that there was no attentional bias to trauma-related images in participants with PTSD or in participants who had recently been exposed to trauma. Contrary to this, a dot-probe task testing attentional bias in a sample of adults who had experienced child abuse found a statistically significant relationship between an attentional bias to happy faces and all types of childhood maltreatment (Fani, Bradley-Davino, Ressler, & McClure-Tone, 2011). The total incidence of childhood maltreatment predicted 26.4%

of the variance in total anxiety and PTSD symptoms (Fani et al., 2011). Results in studies which have examined avoidance and attentional bias using dot-probe with PTSD and trauma-exposed populations have returned varying results (Price et al., 2015; Naim et al., 2015), with Iacoviello and colleagues (2014) finding no significant attentional bias in a PTSD group, matched trauma-exposed group, or healthy controls. Research by Carr and colleagues (2015) employed a dot-probe along with stress manipulation in groups of low- and high- trait anxious individuals, finding attentional bias in females post-stress, but not in males.

Such variable results have led to the reliability of the dot-probe task being questioned, partly due to its reliance on RT measures (Schmukle, 2005). Dot-probe research examining groups of clinically anxious, PTSD, and non-clinical samples have reached differing conclusions (Carr et al., 2015; Kappenman, Farrens, Luck, & Proudfit, 2014), and while dot-probe tasks give a strong measure of avoidance or fixation in response to threatening images, they do not have the ability to identify cognitive processes which accompany these mechanisms.

Event-related Potentials

Event-related potentials (ERP) involve the recording of electrophysiological brain activity using encephalography (EEG). The addition of ERPs to studies which have previously used reaction time alone can be very helpful in understanding the different processes involved in attention (Zhang et al., 2014). This is because ERPs do not rely on reaction time, and can provide evidence of early automatic and later conscious attentional cortical processes (Bar-Haim, Lamy, & Glickman, 2005). The activity targeted is the cortical response to a particular stimulus or occurrence, and the

responses are averaged to create a waveform which shows the reaction of specific brain regions to the stimulus (Kimble et al., 2010). ERPs provide a high temporal resolution measure of activity, and allow conscious and unconscious attentional processes to be discriminated during EEG recording (Kimble et al., 2010).

The early P1 component increases with automatic orienting of visual attention (Fu, Caggiano, Greenwood, Parasuraman, 2005; Zhang et al., 2014), and the N1 component is also modulated by arousal and early selective visual attention (Bar-Haim et al., 2005). The P3 component reflects later conscious allocation of attentional resources (Kimble et al., 2010; Polich & Kok, 1995) and response selection in regards to the stimulus evoking the attentional process (McCarthy & Donchin, 1981). Larger P1 and P3 amplitudes to negative stimuli have been found in individuals with anxiety disorders and/or PTSD in ERP-based attention studies (Bar-Haim et al., 2005; Felmingham et al., 2002; Li et al., 2005), and it has been well-demonstrated that stimuli which require greater amounts of attentional resources result in larger amplitude P3s (Polich & Kok, 1995; Donchin & Coles, 1998; Kimble et al., 2010). ERP has been used extensively in studies investigating attentional bias to threat, most often focusing on the amplitude of the P3 wave (for review, see Hilgard, Weinberg, Proudfit, & Bartholow, 2014).

Research using ERP and RT data to test attentional bias to emotional faces in high-anxious and low-anxious individuals found that ERP may offer a more discriminant measurement of attentional bias to threat with anxious individuals (Bar-Haim et al., 2005). There was no significant difference in the RT results between the high- and low-anxious groups, but a significant difference was found between these

groups on the ERP measure, indicating that highly anxious individuals recorded a larger amplitude on P1 and N1 waveforms when viewing emotional facial expressions (Bar-Haim, et al., 2005). Research by Kappenman and colleagues (2014) supports these findings, yielding no attentional bias to threat in anxious individuals based upon the RT measure; however, increases in N2 ERP amplitude indicated an elevation in early attention allocation to threat, interpreted as an attentional bias (Kappenman et al., 2014). However this bias was not significantly different between high- and low-anxious participants, indicating that high-anxious individuals did not show an increased early allocation of attention to the threatening stimuli compared to the low-anxious group. Zhang and colleagues (2014) employed RT and ERP measures to investigate attentional bias in a trauma-exposed sample of earthquake survivors compared to a healthy control group, finding larger P1 amplitudes and faster RT to congruent trials of a dot-probe task. Following on from this, Zhang and colleagues (2014) noted that the use of ERP measures and trauma-exposed participants without PTSD is limited in current attentional research, recommending that future studies should include a trauma-exposed but non-PTSD group with a matched healthy control group to assess attentional differences. The results of this research, taken together with the reliance of dot-probe tasks on simple RT, support the suggestion that ERPs would be beneficial to include in a study of attentional bias, as they are excellent temporal resolution measures of covert attentional processes and give the ability to discriminate specific processes underlying attention.

In relation to the connection between the mechanisms of the integrative model and ERP components, Bar-Haim and colleagues (2007) suggest that the Resource Allocation System is a rapid and automatic identifier of threat which orients attention

towards the stimulus. This is evidenced by the increased amplitude of P1 and N1 ERP components and increased physiological arousal. The Guided Threat Evaluation system then compares the threat to memory stores, assessing context, giving deeper processing of the stimulus, evidenced by the increased amplitude of the P3 ERP waveform.

Physiological Arousal

Recent trauma victims, individuals with chronic PTSD, and healthy controls were compared in a dot-probe task to investigate whether those with PTSD and recent trauma exposure had an increased attentional bias to threatening images compared to controls (Elsesser et al., 2004). This study introduced a physiological measure of heart rate to the simple RT measure of the dot probe, as a way to test two different theories of stress resulting from trauma. Physiological responses including stress hormones and heart rate offer another method of exploring an individual's attentional processes in response to traumatic stimuli, and it has been well-documented that individuals with PTSD show an elevated heart rate in response to such stimuli (Blanchard, Kolb, Taylor, & Wittrock, 1996; Elsesser et al., 2004). The results of these studies showed distinct physiological effects of both PTSD and trauma exposure, suggestingmthat further use of other physiological measures, such as stress hormones, would allow a greater understanding of the physiological effects of trauma. Stress hormones including noradrenaline can also be evoked using paradigms such as the cold pressor stress (CPS) task, which is used to increase HR, skin conductance, or activation and release of hormones such as noradrenaline or cortisol (Mitchell, MacDonald, & Brodie, 2004). The CPS task was successfully used in research by Carr and colleagues (2015) to manipulate arousal and increase physiological response in women undertaking a dot-probe task. Noradrenaline

has been discussed previously in this review as an important component of attentional bias through physiological arousal, referred to by Markovic and colleagues (2014) as a key part of the BANE model.

Whilst attentional biases to threat have been found consistently in anxiety disorders, this is not the case in PTSD studies, and trauma exposed individuals without PTSD have been minimally included in studies of attentional bias to date. Many attentional bias studies using PTSD groups are limited by major variability between the control and PTSD group, often due to the high rate of comorbidity between PTSD and other disorders (Catani, Adenauer, Keil, Aichinger, & Neuner, 2009). Sources of unreliability across attentional bias findings may also include the reliance on RT measures without considering covert attentional processes (Schmukle, 2005), and neglecting to control for physiological arousal at time of testing. Therefore, this study will extend a paradigm used by Carr and colleagues (2015) by adding ERP measures to a dot-probe task, whilst recording and manipulating physiological arousal indexed by noradrenaline to examine the effects of trauma exposure on attentional bias.

Based upon this literature review, the aim of the current study is to assess attentional biases to threat at baseline and following an acute stress task in individuals who have been exposed to trauma (TE) compared to individuals without trauma exposure (NTE). A dot-probe task will be used to assess attentional bias, with reaction time (RT) and event-related potential (ERP) measures which will enable assessment of both early automatic (P1, N1) and later conscious (P3) attentional processing. Following from previous studies (Carr et al., 2015; Nicholson et al., 2013), it is hypothesised that trauma-exposed individuals will display greater arousal to a CPS task compared to non-

trauma-exposed controls, evident in increased levels of sAA, reflecting noradrenaline, following the CPS task. Secondly, it is predicted that trauma-exposed individuals will display greater attentional biases towards threat following an acute stressor compared to non-trauma-exposed individuals. This will be evident in: (a) faster RT to the threat cue (compared to the non-threat) in the TE group than NTE group, with the difference between groups particularly evident following the acute stress task (CPS task), and (b) Larger P1, N1 and P3 amplitudes to the threat cue (compared to the non-threat) in the TE group than the NTE group, with the difference between groups particularly evident following the acute stress task (CPS task).

Method

Participants

The current study utilised 37 participants, 18 females and 19 males, who were recruited through advertisement at the University of Tasmania, including eligible first-year psychology students who received two hours of course credit in return for participation. Participants were classified into two groups of 18 trauma exposed (TE) and 19 non-trauma-exposed (NTE) according to their responses to the Traumatic Events Questionnaire (TEQ: Vrana & Lauterbach, 1994), meaning that those individuals who reported at least one Criterion A trauma on the TEQ were allocated to the TE group in line with Iacoviello (2014). This includes situations where the individual experienced or witnessed an event with potential or actual serious physical harm or death (American Psychiatric Association (APA), 2013). The Post-Traumatic Stress Disorder Checklist (PCL-5: Weathers et al., 2013) was used to assess the presence of PTSD symptoms

within the sample, identifying any participants who were experiencing the symptoms of PTSD or could be classified as having PTSD.

Participants completed a self-report medical history with exclusion criteria including a psychiatric history apart from PTSD, diagnosed attentional deficits, neurological disease, substance abuse, and traumatic brain injury. Participants taking prescribed psychoactive medication were included due to the timeframe for recruitment, however results were analysed including and excluding the three individuals who reported anti-depressant or anti-anxiolytic medication use, and with no significant effects for medication all were included.

Design

The study utilised a mixed model 2 (Group: NTE/TE) x 2 (Time: Pre,Post) x 3 (Condition: Congruent,Incongruent,Neutral) design, with Group being the between-subjects factor, and Time and Condition the within-subjects factors. Dependent variables include the peak amplitudes of the ERP components of P1, N1, and P3, noradrenaline (NE) level measured by sAA, and reaction time (RT) on the dot-probe task.

Apparatus, Instrumentation, and Materials

Salivary Alpha-Amylase (sAA)

sAA has been validated as a biomarker of endogenous NE that is secreted by the salivary glands, and reflects sympathetic nervous system activation when individuals are under stress (Rohleder & Nater, 2009; Thoma, Kirschbaum, Wolf, & Rohleder, 2012).

Traumatic Events Questionnaire (TEQ)

The Traumatic Events Questionnaire (TEQ: Vrana & Lauterbach, 1994) was administered to all participants before testing began, to identify whether participants had

been exposed to a Criterion A traumatic event, meaning an event in which they were at risk of injury or death, or witnessed someone being in such a situation, through assault, disaster, or war (APA, 2013). The TEQ consists of 11 items assessing nine events which may have occurred in an individual's life, such as a serious accident, being a victim of physical or sexual abuse, or witnessing someone dying in a violent manner. The TEQ has been found to be a valid and reliable measure of traumatic exposure with high test-retest reliability in primary care and non-clinical samples (Crawford, Lang, & Laffaye, 2008) and as such is considered an appropriate measure for TE group allocation.

Post-Traumatic Stress Disorder Checklist for DSM-5 (PCL-5: Weathers et al., 2013).

The PCL-5 is a 20 item self-report scale used to assess an individual's experience of the symptoms of PTSD, as described in the *Diagnostic and Statistical Manual of Mental Disorders – 5th edition* (*DSM-5*: APA, 2015). Possible total scores range from 0-80 using a 5-point Likert scale (0= not at all, 4= extremely). The PCL-5 was used in this study to ensure appropriate allocation of participants into the TE group. Classification of possible PTSD begins with individuals having a score of 38 or higher, no participants in the current study reached this cut-off. The PCL-5 has excellent reliability, with a Cronbach's Alpha level of .93 found in a study by Lowe, Sampson, Gruebner, and Galea (2015), similar to the reliability of earlier iterations of the PCL.

Depression, Anxiety, and Stress Scale (DASS-21: Lovibond & Lovibond, 1995).

The DASS-21 is a 21 item scale which is used to determine an individual's recent mood through a 4-point Likert scale (0= did not apply to me at all, 3= applied to

me very much or all of the time) which assesses three subscales of depression, anxiety, and stress. DASS scores were summed and utilised to assess individuals' variation on level of depressed mood, anxiety, and stress leading up to time of testing, and each subscale was summed separately and individually analysed as a covariate of reaction time measures to ensure that depression, anxiety, and stress levels did not have a significant effect on the data or group allocation. The DASS-21 has been validated as a reliable indicator of separate x of depression, anxiety, and stress (Cronbach's Alpha = .93) and has been suggested to be a more effective measure than the full-scale DASS (Henry & Crawford, 2005).

EEG Apparatus and Recording

ERPs were used to measure cortical activity associated with early and late selective attentional processes. Early selective attention was indexed by ERP components of P1 (recorded over parietal sites), and N1 (recorded over fronto-central sites) and later conscious processing by P3 (recorded over centro-parietal sites). These components were chosen based upon previous research validating their use with trauma exposed and PTSD populations, including the use of P1 (Bar-Haim et al., 2005; Zhang et al., 2014), N1 (Bar-Haim et al., 2005), and P3 (Bar-Haim et al., 2005; Kimble et al., 2010). EEG data was recorded for the dot-probe task using Neuroscan SCAN 4.5 software (Compumedics Neuroscan, 2003) and a SymAmps2 system which was connected to a 32-channel EEG Quick-cap with silver and silver chloride electrodes. EEG recordings were taken from 32 sites with eight midline, parietal, and occipital sites being utilised for analysis based upon inspection of the grand mean average data. Placement of electrodes on the scalp was completed in accordance with the International

10-20 system of electrode placement (Jasper, 1958), with all electrodes referenced by linked mastoids and grounded by an AFz ground electrode. Electro-oculogram electrodes were placed above and below the left eye and at the outer corner of both eyes to allow for control of horizontal eye movement and eye blinks. Electrode impedance was maintained at or below 10 KΩ.

The continuous sampling rate was 1000Hz, amplified at 200Hz, and data was rejected on the basis of horizontal and vertical electro-oculogram activity as well as artefact exceeding +/-125μV. The data was filtered at 30Hz using a low-pass filter, with epoching completed from 100ms pre-stimulus onset to 900ms at stimulus offset. ERP components were selected in relation to a 100ms baseline window before each stimulus onset. The peak amplitude of the P1 and P3 components was calculated by inspecting the maximal positive waveform of grand mean averages between 80-150ms and 200-330ms post-stimulus respectively (Bar-Haim et al., 2005), with N1 peak amplitude calculated by examining the maximal negative waveform between 100-220ms post-stimulus (Bar-Haim et al., 2005).

Cold pressor stress (CPS) task

The CPS task, a widely-used and standardised stress induction task, was employed to induce physiological arousal (Mitchell et al., 2004). This task requires participants to submerge their hand past the wrist into a tub of water maintained at 4 degrees Celsius, which has been found to reliably invoke a parasympathetic nervous system response which includes an increase in the release of NE in the body (Victor et al., 1987). A time limit of three minutes was placed on the task due to the minimum-risk ethics approval. Participants were told to remove their hand from the water at the point

where they could no longer tolerate the discomfort, where they felt pain, or once the three minute upper-limit had been reached. sAA level was assessed at baseline and after the task via saliva sampling to index the level of arousal and NE increase produced by the task.

International Affective Picture System images

One-hundred and fifty-two neutral and 75 negative images were selected from the International Affective Picture System (IAPS: Lang, Bradley, & Cuthbert, 2008). The neutral images had a mean valence and arousal of 5.62 (.98) and 3.67 (.89) respectively, while the negative images had a mean valence and arousal of 2.92 (.92) and 5.86 (.82) respectively. The IAPS set of images consists of over 1000 colour pictures and was developed as a tool to elicit a range of emotions in research participants which would be possible to use across cultures and ages. Images range from highly positive, such as puppies, to neutral, such as a table, to highly negative, such as a mutilated body, and provide a standardised resource for researchers studying attention and emotion (Lang et al., 2008). Participants were asked to complete a picture rating task created using the images presented in this study to assess how the sample viewed them, through a nine-point valence scale (1=highly negative, 9=highly positive) and a nine-point arousal scale (1=very boring, 9=very exciting). This allowed later analysis of whether there was a significant difference between groups in these ratings.

Dot-probe task

The dot-probe task was created in line with tasks used by Carr and colleagues (2015), and displayed on a computer screen using a custom NeuroSCAN STIM computer. Each dot-probe trial involved an initial black screen for 400ms, followed by

two paired IAPS images being displayed on screen in line with a paradigm used by Schmukle (2005), either a neutral/neutral pair or a negative/neutral pair. Stimulus duration of 1000ms was used as a replication of Carr and colleagues' paradigm (2015). Immediately following offset of the images, a white dot appeared on the left or right of the screen, depending on the type of trial. The congruent condition involved the dot-probe appearing on the same side of the screen as the negative image in the previous pair, while the incongruent condition was the opposite. The neutral condition had the dot-probe following a pair of neutral images; therefore the location of the probe did not matter and left or right presentation of the dot-probe was randomly distributed within the neutral pairs. Participants then had 2000ms to select the A (left screen) or L (right screen) key on the keyboard to indicate probe location before the trial cycle begins again. *Figure 3* below contains an example neutral and congruent dot-probe trial.

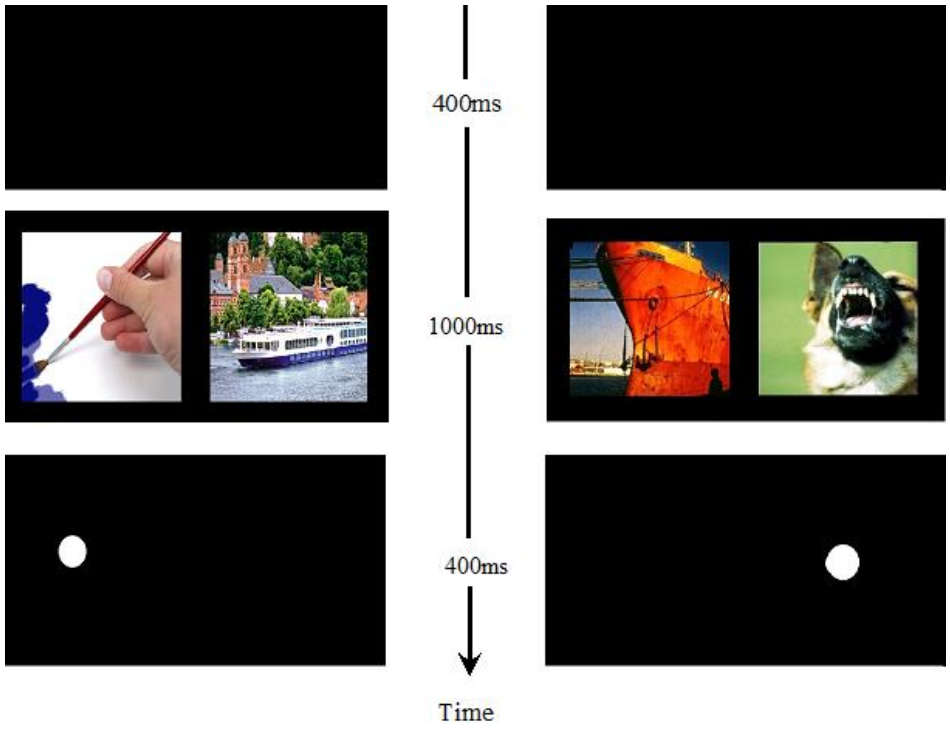

Figure 3. Example neutral (left) and congruent (right) trials of the dot-probe task used in the current study. The 'time' bar shows the presentation duration of each screen.

Procedure

The study procedure is shown below in *Figure 4*. Written informed consent was obtained from participants after they read an information sheet and asked any questions they may have had (information sheet and consent form provided in Appendix A and B respectively). Participants then provided an initial saliva sample to assess baseline NE levels using salivary alpha-amylase (sAA). The self-report medical history, TEQ, DASS-21, and PCL-5 were completed before the EEG cap was prepared and securely fitted to the scalp (forms and scales in Appendix D, E, F, and G respectively). Participants were seated 50cm from the NeuroSCAN computer screen and given full instructions about how to complete the dot-probe task (see Appendix H). All participants undertook five practice trials using IAPS images which had similar valence and arousal to the experimental set but were not included in the actual task. Each participant then completed two counterbalanced blocks of 57 trials. Block A and B were constructed of different images with an equal distribution of congruent, incongruent, and neutral trials, and all participants completed them in the same order. Following the 57 trials of block A, participants undertook the CPS task, after which they provided a second saliva sample to assess the effect of stress on sAA following the cold-pressor task, before beginning block B.

Following the completion of the 57 trials of block B, the EEG cap was removed, and participants were asked to complete the picture rating task to rate the valence and arousal of the IAPS images presented to them in the dot-probe task. These picture rating valence and arousal means were compared across TE and NTE groups to assess whether the TE group found the images more negative and arousing than the NTE group.

Figure 4. Flowchart depicting the procedure of the current study.

Testing time averaged 90 minutes including placement and removal of the EEG cap, dot-probe task, saliva sampling, CPS task, and picture rating task. Participants had the opportunity to ask any follow-up questions before departing.

Salivary Alpha-Amylase

Analysis of NE was undertaken by collecting saliva samples from participants using the passive drool method. Salivary NE levels were analysed by standard assays of sAA at Macquarie University Pathology Lab with samples stored frozen at -20°C until assay. Estrogen and progesterone were also analysed at the same time as sAA, however results of this analysis were not examined due to the scope of this project. On the day of assay the samples were thawed and analysed using commercially available kits according to the manufacturer's instructions (Salimetrics, USA). Thawed samples were centrifuged at 1500 x g for 15 minutes to collect clear saliva and this saliva was used without further processing for all assays. All samples were brought to room temperature before adding to assay wells and all samples were analysed in duplicate.

Analysis

Experimental data was analysed in separate 2(Group: TE,NTE) x 2(Time: Pre,Post) x 3(Condition: Congruent,Incongruent,Neutral) mixed model repeated measures ANOVAs for RT and ERP components; ERP analysis also included Site as a factor. For these analyses, the between factor was Group, while Condition, Site, and Time were the within factors. Statistics interpreted were taken from the multivariate

tables produced by SPSS-v21, to eliminate the need to consider sphericity, in line with processes used by Tabachnick & Fidell (2012). Salivary data was analysed by separate 2(Group: TE,NTE) x 2(Time: Pre,Post) repeated measures ANOVAs for sAA data. The distribution of sexes across TE and NTE was analysed using a 2x2 Chi square test of independence. Effect sizes for significant main effects and interactions as well as 95% confidence intervals were analysed, significance was set at an alpha level of p=<.05.

Results

Demographic and clinical data

Univariate ANOVAs and a Chi square test of independence were conducted on demographic and clinical data and a summary of findings are presented below in *Table 1*. For SPSS data output of all analyses, see Appendix P (Zip file/disc).

Table 1.

Demographic and clinical data of TE and NTE groups

Variable	TE	NTE	Statistic	p	η^2_p
Sex	7F, 11M	11F, 8M	$x^2 = 1.34$	.248	---
Age	26.94 (5.92)	23.63 (6.26)	$F = 2.72$	.108	.072
PCL-5	13.89 (11.97)	6.32 (5.84)	$F = 6.09$	.019	.148
DASS-D	3.78 (4.55)	1.16 (2.04)	$F = 5.22$	.029	.130
DASS-A	2.72 (3.23)	1.58 (1.77)	$F = 1.81$	.188	.049
DASS-S	5.33 (3.92)	2.58 (2.78)	$F = 6.13$	.018	.149

As can be seen in *Table 1*, there were no significant differences between groups on mean age or distribution of sexes. As expected, there were significant group differences in PTSD severity scores measured by the PCL-5, and significant group differences in the Depression, Anxiety and Stress subscales of the DASS-21, with the TE group displaying significantly larger scores than the NTE group.

Salivary Alpha Amylase Data

Data for sAA was analysed using a 2(Group: TE,NTE) X 2(Time: Pre,Post) repeated-measures ANOVA, which identified that there was a significant main effect of time, $F(1,35)=4.91, p=.033, n_p^2=.123, \lambda=.877$, revealing that the baseline level of sAA taken pre-stress ($M=96.89$, SD 11.41) significantly increased following the stress induction ($M=112.26$, SD 13.85). See *Figure 5* below for visual description of means and confidence intervals. A significant main effect of Group was not identified, $F(1,35)=.009, p=.926, n_p^2=.000$, and the Time x Group interaction was also not significant, $F(1,35)=.651, p=.425, n_p^2=.018, \lambda=.982$.

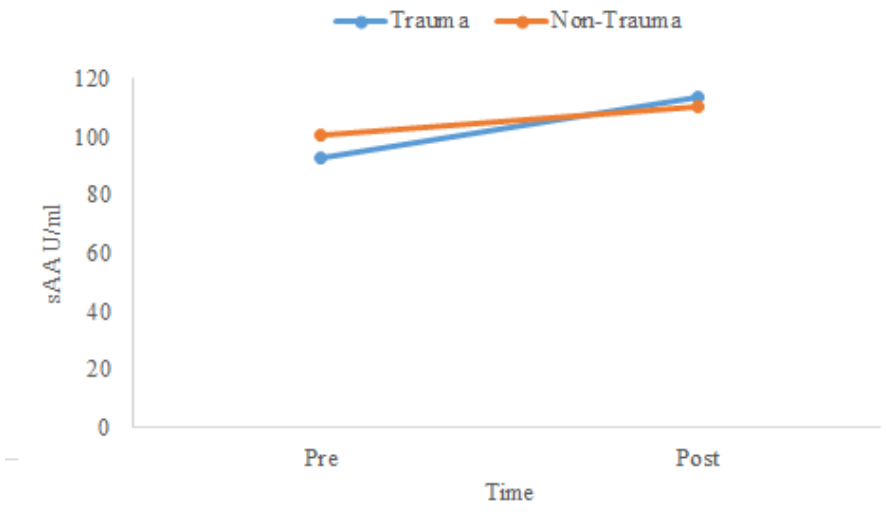

Figure 5. Significant increase in salivary alpha-amylase from Pre to Post observed in both TE and NTE groups.

Behavioural Data

For the RT data, a 2(Group: TE,NTE) x 2(Time: Pre,Post) x 3(Condition: Congruent,Incongruent,Neutral) repeated measures ANOVA revealed a significant main effect of Time, $F(1,35)=37.18$,$p=<.001$,$\eta^2_\rho=.515$,$\lambda=.485$, with RT significantly faster post-stress (*M*=283.55, *SD* 6.18) than at baseline (*M*=303.80, *SD* 6.29). This analysis also revealed a significant main effect of Group, $F(1,35)=4.77$,$p=.036$,$\eta^2_\rho=.120$, with the NTE Group significantly faster (*M*=280.54, *SD* 8.38) than the TE Group (*M*=306.81, *SD* 8.61) across all levels of Condition and Time. No significant main effect of Condition was observed, $F(2,34)=.345$,$p=.711$,$n_p^2=.020$,$\lambda=.980$, nor significant interactions between any of the variables, non-significant findings are shown in Table 2, Appendix I.

ERP Data

ERP amplitude data was screened for missing values and outliers, with no missing values found. Outliers were categorised as those scores which exceeded three standard deviations from the mean score of each Group, and such scores were replaced with a score just inside of three standard deviations, congruent with statistical literature (Tabachnick & Fidell, 2012). In the current study, out of 222 cases total (6 conditions x 37 participants), the incidence of outliers in the TE group was .9% (1 case), while the incidence of outliers in the NTE group was .45% (2 cases).

Grand Mean Averages

Grand mean average waveforms for TE and NTE groups are shown below in *Figures 6, 7, 8, and 9*. Analyses of the amplitudes of the P1, N1, and P3 ERP components were completed on midline and parietal sites in line with paradigms commonly used in ERP studies of attentional bias (for review, see Karl et al., 2006). The P1 amplitude was maximal at 120-130ms at parietal sites (P3,P4,PZ), while N1 amplitude was maximal at 170-180ms at fronto-central sites (CZ,FCZ). Finally, P3 amplitude was maximal at 275-295ms at centro-parietal sites (CZ,CPZ,PZ). The Post-stress average images typically show a tightening of ERP amplitudes across Condition, meaning the amplitudes for each Condition are more differentiated in the Pre-stress grand mean averages, and consolidated together more tightly at Post-stress.

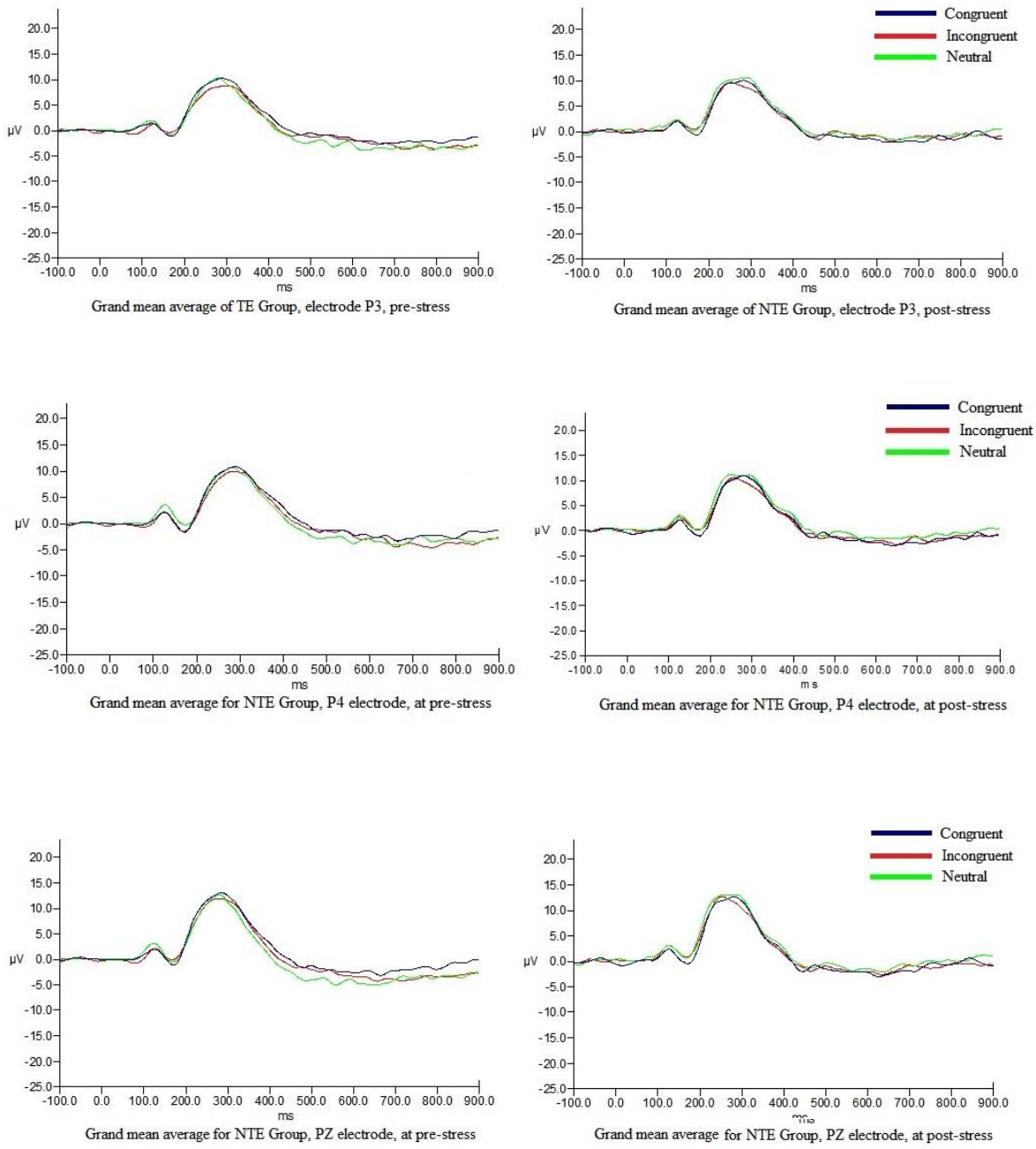

Figure 6. NTE Group: Pre-stress and Post-stress grand mean average images are provided for each Site, with the averaged amplitudes for each Condition shown in colour: Blue for Congruent, red for Incongruent, and green for Neutral.

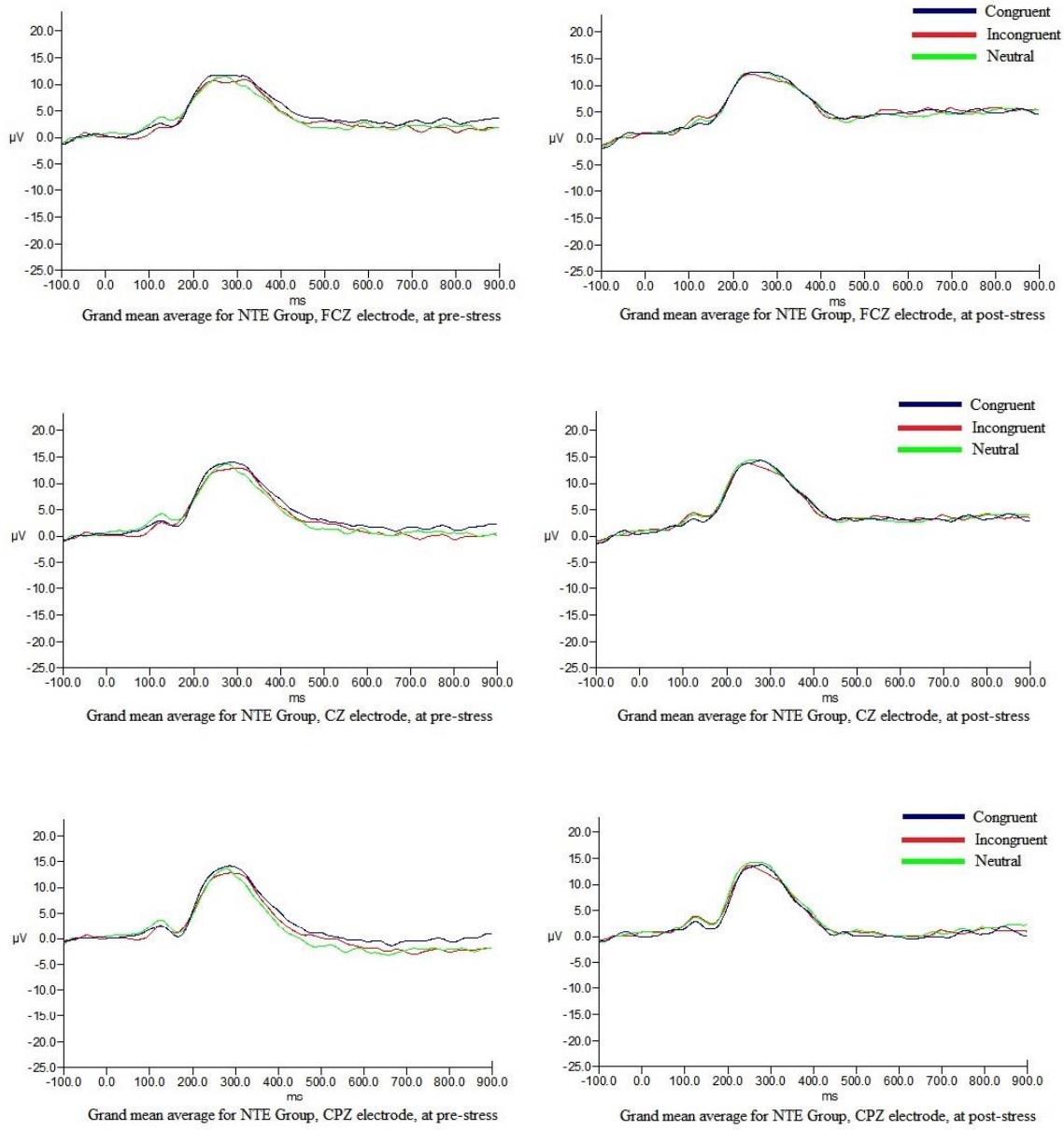

Figure 7. NTE Group: Pre-stress and Post-stress grand mean average images are provided for each Site, with the averaged amplitudes for each Condition shown in colour: Blue for Congruent, red for Incongruent, and green for Neutral.

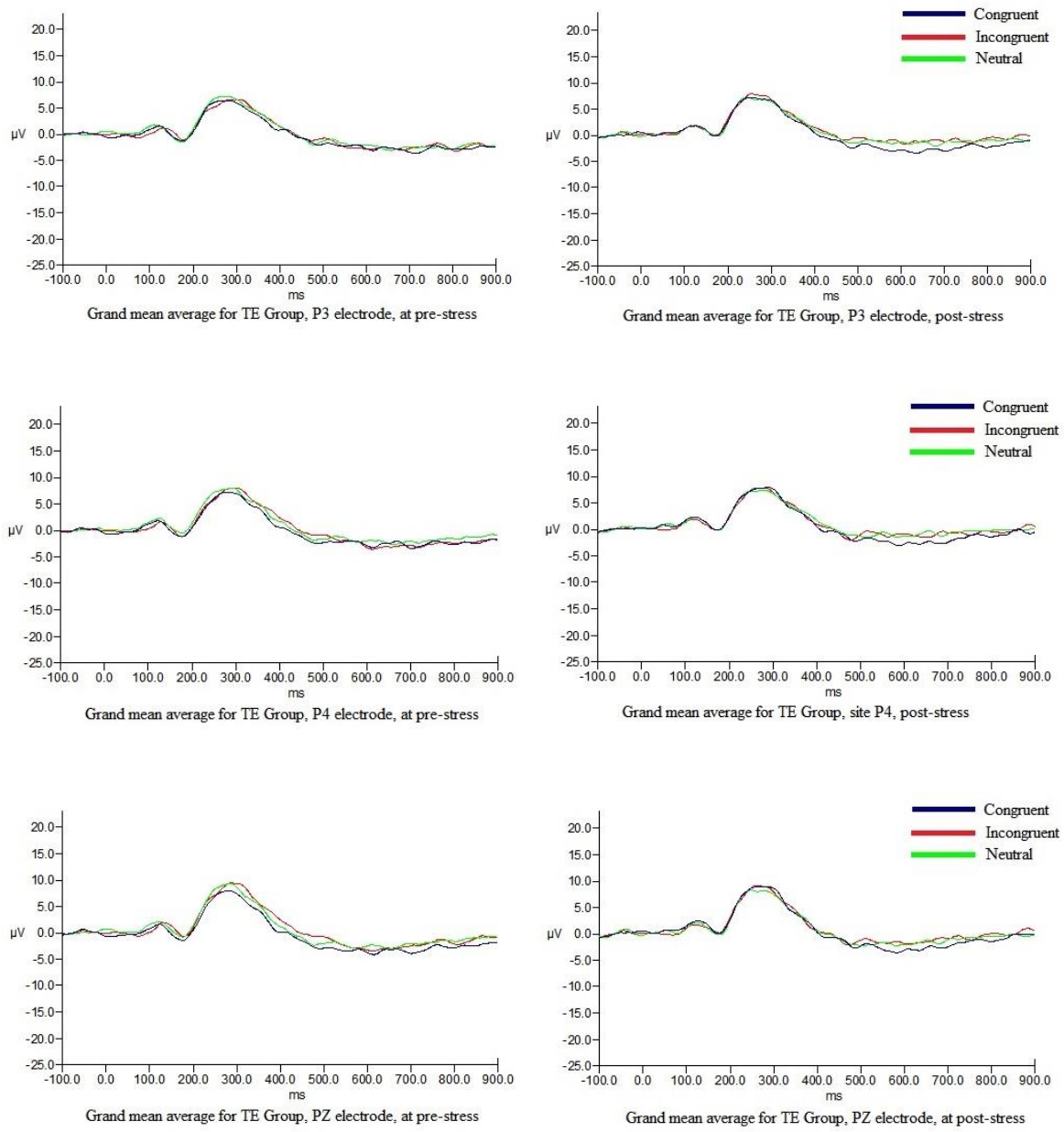

Figure 8. TE Group: Pre-stress and Post-stress grand mean average images are provided for each Site, with the averaged amplitudes for each Condition shown in colour: Blue for Congruent, red for Incongruent, and green for Neutral.

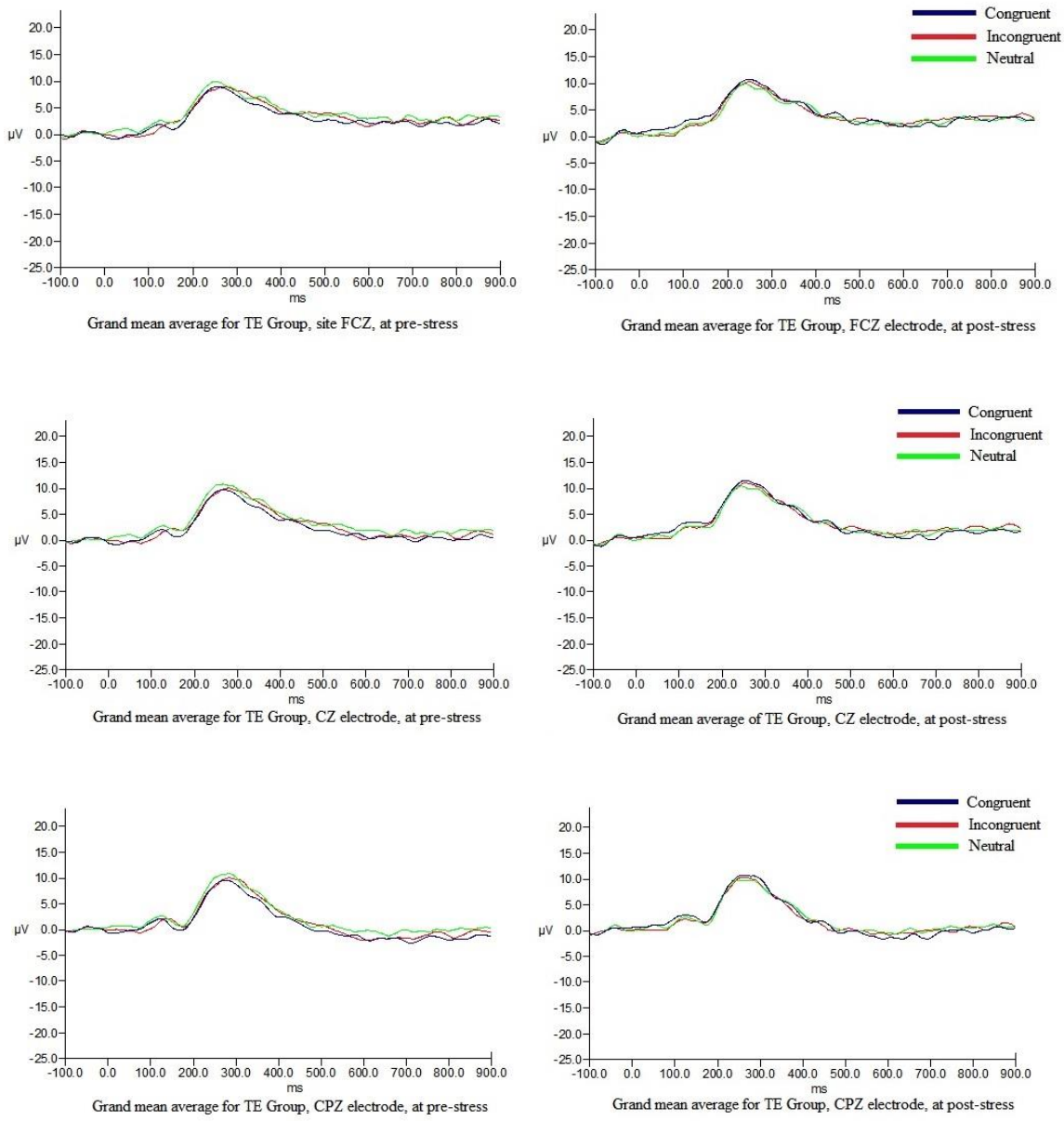

Figure 9. TE Group: Pre-stress and Post-stress grand mean average images are provided for each Site, with the averaged amplitudes for each Condition shown in colour: Blue for Congruent, red for Incongruent, and green for Neutral.

ERP Components

P1 Component: Amplitude

For the P1 amplitude at parietal sites, a 2(Group: TE,NTE) x 2(Time: Pre,Post) x 3(Condition: Congruent,Incongruent,Neutral) x 3(Site: PZ,P3,P4) repeated measures ANOVA revealed a significant main effect of Site, $F(2,34)=4.74$,$p=.015$,$\eta^2_\rho=.218$, $\lambda=.782$, with PZ amplitude ($M=3.38$, SE .469) significantly higher than P3 ($M=2.82$, SE .409), $p=.015$, [.092,1.04]. There was no significant main effect of Group, $F(1,35)=.008$,$p=.930$,$n_p^2=.000$; Time, $F(1,35)=1.20$,$p=.281$,$\eta^2_\rho=.033$, $\lambda=.967$; or Condition, $F(2,34)=2.22$,$p=.124$,$\eta^2_\rho=.115$,.885, and no significant interactions between variables, as shown in Table 3, Appendix J.

N1 Component: Amplitude

For the N1 amplitude at fronto-central sites, a 2(Group: TE,NTE) x 2(Time: Pre,Post) x 3(Condition: Congruent,Incongruent,Neutral) x 3 (Site: FCZ,CZ) repeated measures ANOVA revealed a significant main effect of Time, $F(1,35)=4.34$,$p=.045$, $\eta^2_\rho=.110$,$\lambda=.890$, with N1 amplitude significantly higher at baseline ($M=-.226$, SE .503) than N1 amplitude post-stress ($M=.701$, SE .641), $p=.045$, [-1.829, -.024]. There was no significant main effect of Group, $F(1,35)=.659$,$p=.422$,$n_p^2=.018$; Site, $F(1,35)=.047$,$p=.830$,$\eta^2_\rho=.001$, $\lambda=.999$; or Condition, $F(2,34)=.1.54$,$p=.229$,$\eta^2_\rho=.083$, $\lambda=.917$, and no significant interactions between variables, see Table D, Appendix K.

P3 Component: Amplitude

For the P3 amplitude at centro-parietal sites, a 2(Group: TE,NTE) x 2(Time: Pre,Post) x 3(Condition: Congruent,Incongruent,Neutral) x 3(Site: PZ,CPZ,CZ) repeated

measures ANOVA revealed a significant main effect of Site, $F(2,34)=5.323, p=.010, \eta^2_\rho=.238, \lambda=.762$, with P3 amplitude maximal at site CZ. Sidak pairwise comparisons revealed that PZ amplitude (M=12.49, *SE* .63) was significantly lower than CPZ (*M*=13.67, *SE* .79), *p*=.007 [-2.06,-.279] and CZ (M=14.25, *SE* .90), p=.010, [-3.14,-3.56]. There was no significant main effect of Time, $F(1,35)=1.737, p=.196, \eta^2_\rho=.047, \lambda=.953$, nor Condition, $F(2,34)=.06, p=.942, \eta^2_\rho=.004, \lambda=.996$, however, there was a significant main effect of Group, $F(1,35)=9.35, p=.004, \eta^2_\rho=.211$, with P3 amplitude in the TE Group (*M*=11.18, *SE* 1.07) significantly reduced compared to P3 amplitude in the NTE Group (*M*=15.76, *SD* 1.04). This main effect was superseded by a significant Group x Condition x Time interaction, $F(2,34)=4.015, p=.027, \eta^2_\rho=.191, \lambda=.809$, investigated further using breakdown two-way repeated measures ANOVAs.

Examination of Group x Condition at Pre and Post, and Group x Time at each level of Condition revealed no significant differences (see Table 5 in Appendix L for statistics for both analyses). Finally, a two-way repeated measures ANOVA examined the effect of Condition x Time for each Group, finding a significant interaction between Condition and Time for the TE Group, $F(2,16)=5.07, p=.020, \eta^2_\rho=.388, \lambda=.612$, whereas, the Condition x Time interaction for the NTE Group was not significant, $F(2,17)=.653, p=.533, \eta^2_\rho=.071, \lambda=.929$. Sidak pairwise comparisons for the TE Group revealed that the P3 amplitude significantly increased from Pre (*M*=10.26, *SE* .84) to Post (*M*=11.93, *SE* .92) only to Congruent trials, *p*=.047, [-3.31,-.023], which did not occur in the NTE Group. This interaction effect is presented below in *Figure 10*.

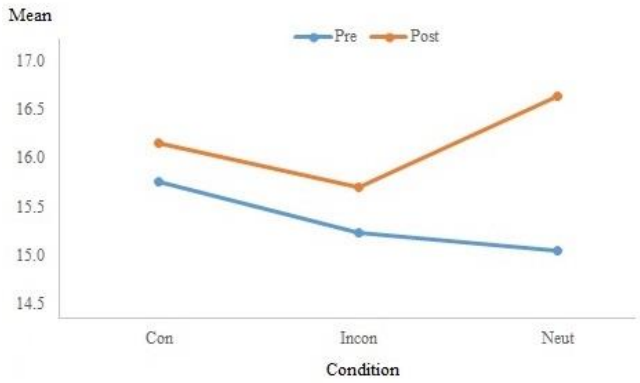

Figure 10. Effect of Condition x Time for the NTE Group across P3 component sites. 95% CI Pre [12.47, 18.23] Post [13.39, 18.94]

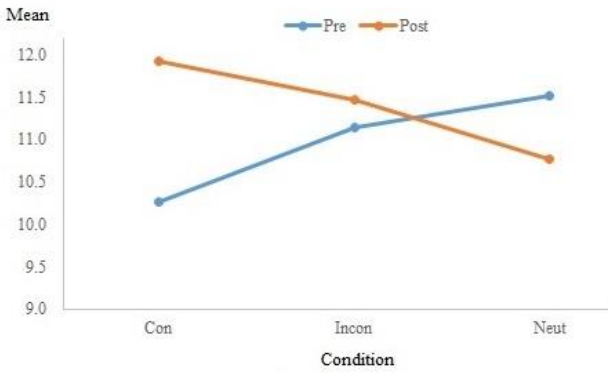

Figure 11. Effect of Condition x Time for the TE Group acoss P3 component sites. 95% CI Pre [9.49, 12.46] Post [9.70, 13.07]

Picture Rating Task Data

Separate univariate ANOVAs were conducted on the picture rating data using Group (TE,NTE) as the between-subjects factor, to determine that there were no significant differences between the TE and NTE groups in regards to the arousal and valence ratings of the threat and neutral IAPS images used in the dot-probe task. Means and standard deviations (Table 6), and all non-significant main effects and interactions (Table 7) can be found in Appendix M and N respectively.

Discussion

This study examined the effect of trauma exposure on attentional biases towards threat before and after a stress induction using a dot-probe task, whilst recording RT with the addition of ERP components P1, N1, and P3 to allow the discrimination of the covert processes of attention. Salivary noradrenaline measures were included between blocks of the dot-probe to test the effect of a stress induction on ERP amplitude and reaction time using the cold-pressor stress task. The major finding was that trauma exposed individuals had significantly higher P3 ERP amplitudes to the congruent (threat) condition of the dot-probe task than the non-trauma-exposed group, following

the cold-pressor stress task, and this group difference was not seen prior to the stress induction This finding suggests that greater attentional resources were allocated to threatening stimuli than neutral stimuli in the trauma-exposed group, compared to the non-trauma-exposed group, but only following an acute stressor,

Noradrenaline and Stress Induction

Both the trauma-exposed (TE) and the non-trauma-exposed (NTE) group displayed significant increases in sAA levels (reflecting noradrenaline) following the CPS task, indicated by a main effect of time, indicated by a main effect of time. This finding validated the effect of the CPS task, and confirmed previous literature (Mitchell et al., 2004). However, the hypothesis that noradrenaline levels measured by sAA would be higher in TE than NTE was not confirmed, as there was no significant group difference or interaction between group and time observed. This result is in contrast to previous literature such as Southwick and colleagues (1999) who suggested that noradrenaline levels show increased responsivity in individuals with PTSD. A recent extensive meta-analysis by Stark and colleagues (2015) reviewing fMRI studies investigating functional differences in the brains of people with PTSD and trauma exposure suggested that increased noradrenergic system response may be responsible for changes in the brain post-trauma.

It is possible that the contradictory findings of the current study compared to previous research may be due to the composition of the groups in the current study: for example, Lemieux and Coe (1996) found a significant difference in noradrenaline levels between a PTSD group and healthy control group who did not differ on other demographic or clinical factors, however, the groups used in the current study were not

clinical samples. The majority of studies which employ measures of stress hormones such as noradrenaline use a clinically diagnosed group, most often with PTSD, compared to a matched healthy control group (for review, see Southwick et al., 1999) and use of trauma-exposed individuals without PTSD is limited. The level of trauma that participants have been exposed to is an important consideration in the current study, it is possible there may be some threshold level of trauma exposure required before physiological or brain-based changes occur.

Attentional Bias: Reaction Time Data

It was hypothesised that the TE group would have a significantly faster RT to the congruent dot-probe trials following the stress induction, reflecting an increased attentional bias to threat following after acute stress. However, both the TE and NTE groups had a significant decrease in RT to all conditions following the stress induction, meaning that this hypothesis was not supported. The results of the analysis of behavioural data showed that the NTE group was faster at both pre- and post-stress for all conditions, assessed by RT in the dot-probe task. This result is in contrast to a vast body of experimental literature which has found attentional biases in individuals with a range of anxiety disorders (for review, see Pergamin-Hight et al., 2015), as well as trait-anxiety (Carr et al., 2015) and PTSD (Fani et al., 2012). For this reason, conclusions relating to attentional bias effects may not be drawn from the current study because there was no reliable condition effect indicating attentional bias.

The lack of an overall condition effect whereby there would be faster RTs to the congruent trials means that there was no evident attentional bias effect in the dot-probe task. This may be due to the participants in both groups not perceiving the negative

IAPS images used as particularly threatening or negative. Inspection of the means from the picture rating task analysis for both image types revealed that the valence and arousal ratings given to neutral images and threat images did not significantly differ, and both types of image were rated as neutral (neutral being 4.5 on the 9-pt scale). This indicates that neither group found the threat images to be more negative than the neutral images used, which is a major limitation of the current study, and the primary reason that no condition effect was identified. Reasons for this could include participant fatigue, as each participant completed the picture rating task for approximately 15-20 minutes following the other sections of the paradigm, which generally totalled 90 minutes. If participants were bored or tired, the simplest choice for them to make on the scales of the picture rating would be 'neutral' at 4-5 on the scale, which may account for the lack of perceived negativity in the image set used.

Regarding the Bar-Haim model (Bar-Haim et al., 2007), this result may mean that the PTES did not tag the IAPS images as threatening, meaning minimal arousal was generated and no condition effect was found, as further processing by the GTES was not required. This result is unexpected, as the images used in the dot-probe task were chosen based on standardised IAPS norms and similar images have revealed clear valence and arousal effects in studies completed in the same University of Tasmania lab (Gardener, Carr, MacGregor, & Felmingham, 2013; Nicholson et al., 2013) . This unexpected result requires further collection and analysis in subsequent samples to assess the reliability of these IAPS images in creating valence and arousal effects.

A further possible explanation for the lack of a condition effect reflecting an attentional bias towards threat may relate to the stimulus duration time. In an attempt to

account for the lack of condition effect, a post-analysis review of 20 dot-probe articles published between 2004-2015 was conducted (see Table 8 in Appendix O for article details including stimulus duration, sample size, and whether attentional bias was found), with one factor standing out as a potential explanation for the non-existent attentional bias to threat in this sample. Out of 20 peer-reviewed empirical studies examined, 15 returned a result confirming an attentional bias to threat in anxious, PTSD, and trauma-exposed populations of adults and children. Of these 15 studies, 13 employed a stimulus presentation time of 600ms or less in the dot-probe task, while the current experiment used a stimulus duration of 1000ms. The reason for the stimulus duration chosen in the current study was the adoption of a successful paradigm used by Carr and colleagues (2015) that was extended in this study to include ERP measures in a design which already included a dot-probe task and sAA measure. Furthermore, in studies using longer presentation times from 1000-2000ms, (Bar-Haim et al., 2010; Salum et al., 2012), attentional avoidance of threat was found rather than attentional bias to threat, which is a possible explanation of the inability of the current study to register an attentional bias to threat in the sample. Recent research by Iacoviello and colleagues (2014) has investigated a phenomena described as attention bias variability (ABV), which indexes the amount of fluctuation between bias and avoidance, using a dot-probe task in individuals with PTSD and non-PTSD trauma exposure. The findings indicate that higher ABV predicts PTSD symptom severity in both combat-exposed individuals with PTSD and trauma-exposed individuals, with a significant finding that prior to deployment, ABV was not detected, however following return from service, ABV present along with PTSD symptoms (Iacoviello et al., 2014). This research was

extended by Naim and colleagues (2015) with the inclusion of PTSD groups with differing types of trauma exposure, an acute stress combat group, and high- and low-anxious controls. Elevated ABV was found in both PTSD groups compared to the anxious groups, with the highest ABV found in post-combat PTSD over all other groups (Naim et al., 2015). Taken together, these findings suggest that future research should investigate neural processed involved in avoidance and hypervigilance; and Naim and colleagues also suggest that variable stimulus durations in dot-probe tasks may help uncover the involvement of attentional subcomponents such as facilitation and disengagement.

To directly test the effect of stimulus duration on attentional bias, Koster, Crombez, Verschuere, and De Houwer (2004) employed three different stimulus durations: 100ms, 500ms, and 1250ms. Utilising a sample with a group of high-trait anxious and a group of low-trait anxious participants in a visual probe task, attentional bias to threatening images was detected in both the 100ms and 500ms paradigms, but attentional avoidance was found at 1250ms (Koster et al., 2005). This finding suggests the possibility that shorter stimulus durations allow the detection of attentional biases, while attentional avoidance may be more evident at longer stimulus durations. The stimulus duration used in the current task falls in the middle of this window, which may explain the lack of condition effect in the current study.

In relation to the lack of condition effects or group x condition effects in RT data, group composition may play a role. The most robust attentional bias effects have been found in groups with clinically diagnosed PTSD, anxiety disorders, and phobias, whereas the TE group in the current study was not a clinical sample. This group was

composed of individuals who had been classified as trauma-exposed based upon their experience of a criterion-A trauma on the TEQ (Vrana & Lauterbach, 1994), but no clinical diagnoses had been made. Three participants listed a PTSD diagnosis in their psychological history, however no participants reached the PCL-5 cut-off score of 38 to indicate a PTSD diagnosis (Weathers et al., 2013). Further to this, the nature of the participants' trauma exposure was likely to have been quite variable, and due to the scope of the project the type of trauma was not disclosed. The variable nature of trauma-exposure was identified by Nicholson and colleagues (2013) as a limitation of their study examining noradrenaline and cortisol increases related to intrusive memory experience in a sample of people with PTSD. Related to this is the issue of trauma-relevant images, with a meta-analysis by Pergamin-Hight and colleagues (2015) returning results suggesting that trauma-relevant stimuli (such as images of combat violence shown to veterans with PTSD) are selectively processed with a significantly stronger bias than non-relevant threatening stimuli. This issue could extend to the present study, as due to ethical constraints, the threatening IAPS images used in the dot-probe task could not be matched to the participants' actual type of trauma experience, nor were they chosen from the most aversive categories, thereby minimising the capacity of the images to provoke attentional bias.

As RT cannot identify covert attentional processes, ERP measures were included in the current study to further investigate the processes that underlie attentional bias to threat, this inclusion was also in response to criticism of the reliability of dot-probe tasks as a measure of attentional bias (Schmukle, 2005). ERP was chosen based upon recommendations that EEG should be added to traditional attentional-bias paradigms to

better discriminate attentional processes underlying threat response (Catani et al., 2009; Naim et al., 2015), as well as criticisms surrounding the limited use of ERP measures in studies examining individuals with trauma-exposure who have not developed PTSD (Zhang et al., 2014).

Attentional Bias: ERP Data

P1 and N1 Amplitude

It was predicted that attentional bias measured by increased amplitudes of early automatic attention ERP components of P1 and N1, and later conscious attention ERP component P3 would be larger in the TE group following the cold-pressor stress task. This hypothesis was not confirmed for N1 and P1, as there was no significant group effect or interactions with group for the N1 and P1 amplitude. This means that in this sample there was no evidence of an attentional bias to threat in early automatic attentional processes. This finding is in contrast to Zhang and colleagues' (2014) findings that P1 amplitudes were larger to threatening stimuli in trauma-exposed individuals compared to both the PTSD group and healthy controls, as well as the majority of ERP research that suggests P1 is an index of early visual attention which is implicated in attentional bias to threat (Bar-Haim et al., 2005; Fu et al., 2005; Li et al., 2005). The amplitude of the N1 component to threatening stimuli did not differ significantly between groups, in line with research by Li and colleagues (2005) which found no difference between high- and low-anxious participants on N1 amplitude. Research by Bar-Haim and colleagues (2005) found that negative emotional images produced increased N1 amplitudes across the entire sample, with no effect of group when using high- and low-anxious groups. N1 was included as it is a measure of

discrimination in attention (Bar-Haim et al., 2005; Hillyard et al., 1995), however evidence of an attentional bias to threat in N1 has been mixed and studies utilising N1 have been limited.

P3 Amplitude

It was also hypothesised that the trauma-exposed group would show increased P3 amplitudes to congruent trials following the stress task; this hypothesis was supported due to a significant interaction identified between group, time, and condition. This interaction was further broken down to reveal a significant condition x time interaction in the TE group only, where P3 amplitude was found to increase to congruent (threat) trials following the CPS task. This finding indicates that, in line with previous research (Johnson, Allana, Medlin, Harris, & Karl, 2013; Kimble et al., 2010), greater attentional resources were allocated to the threatening images compared to the non-threatening images in the trauma-exposed group; but this has typically been found in PTSD samples. Interestingly, the current study found this result in trauma-exposed individuals but only following a stress induction. P3 has been the most widely studied ERP component in relation to PTSD, however ERP studies utilising a non-PTSD trauma-exposed control group have been limited (Zhang et al., 2014). The results of the current study provide support for previous findings where trauma history predicted changes in P3 amplitudes significantly more than PTSD scores predicted alterations to P3 (Kimble et al., 2010), in line with a review by Johnson and colleagues (2013) which found that non-symptomatic trauma survivors could be distinguished from healthy controls by their P3 amplitude. This review found that P3 amplitude was significantly larger to threatening stimuli in PTSD groups compared to both non-symptomatic trauma

survivors and healthy controls (Johnson et al., 2013). Stark and colleagues (2015) suggest the importance of studying trauma-exposed individuals who have not developed PTSD because while it can be seen that stress has an impact on the brain outside the development of PTSD, the long-term effects of trauma exposure are unclear. The results of the current study support this suggestion due to the significant differences seen in the P3 amplitude in the trauma-exposed group compared to the non-trauma-exposed group, which indicate that Stark and colleagues' (2015) identified neural differences may be present in this trauma-exposed sample.

Several contributing factors may have been responsible for the increased P3 amplitudes found in PTSD and trauma-exposed groups in the context of threatening stimuli, with a range of functional differences being identified in the brains of individuals with PTSD and non-PTSD trauma exposure. Hyperactivation of the parietal cortex to threatening images was found by Catani and colleagues (2009) to be present in tortured war victims with PTSD and refugees without PTSD who fled the same conflict, but not healthy controls with similar backgrounds minus trauma exposure. These researchers concluded that the response pattern of the superior parietal cortex to threatening imagery differentiates PTSD and trauma-exposed from healthy controls (Catani et al., 2009), similar to findings by Johnson and colleagues (2013) discussed previously. These results combine to support suggestions by Stark and colleagues (2015) that the experience of trauma may cause enduring differences in the brain, even when PTSD does not develop in people exposed to trauma. Taken together, the results of the aforementioned reviews and empirical studies offer a functional explanation of the increased P3 amplitudes to threatening imagery seen in the trauma-exposed group in the

current study. While ERP and fMRI are different methodologies investigating discrete processes and areas of the brain, it is important to note the wealth of findings in empirical literature which suggest that trauma exposure alone has enduring and measurable effects on the brain. This suggests that future research investigating the effects of trauma exposure on the brain would do well to include an investigation of functional differences in the brain in trauma-exposed individuals in comparison to the more traditionally investigated PTSD and healthy control groups.

Limitations and Future Directions

The major limitations of the current study have been discussed, including the neutral valence and arousal effects for the IAPS images used in the dot-probe, which may be a key factor in the failure to find attentional bias effects, and the stimulus duration used within this task which may have reduced the sensitivity in finding attentional biases. Considerations for future research would involve the need to include several stimulus duration windows, for example, 500ms, 1000ms, and 1500ms presentations, similar to Koster and colleagues (2004). The current study used one stimulus duration in an attempt to replicate and extend Carr and colleagues' (2015) research and to avoid a potential five-way design in an honours project due to adding additional stimulus durations; however, the results of this study indicate that varying the presentation time may be an important consideration in future. Attention also needs to be given to the use of the IAPS images in the present study: due to minimal-risk ethics requirements, the most negative category of images was unable to be used in the present study, which future research may need to address when trying to achieve a condition affect and show attentional bias to threat.

The current study may also have been limited by the omission of control group who did not complete the CPS task which would have allowed the separation of stressor effects from practice effects that may have affected the post-stressor block B. Such a group would complete a warm water control, where the process is identical to the cold-pressor stress task but the water is maintained at 37 degrees-Celsius instead (Deuter et al., 2012). Research by McHugh and colleagues (2010) concluded that the use of a control group who do not complete a stress induction would give a better understanding of the effect of stress compared to the effect of learning. Finally, menstrual phase was not controlled for in the current study as this would have required a significantly larger sample size and extended the timeline far beyond the scope of an honours study; however, the use of any hormonal method of contraception was recorded. It has been suggested by researchers such as McHugh and colleagues (2010) that menstrual phase has an impact on the production and release of stress hormones such as noradrenaline; while Thoma and colleagues (2012) emphasised the importance of controlling for menstrual phase based on findings of significant stress hormone production differences between women on oral contraceptives and women in a natural menstrual cycle, as well as differences between cycle phase at time of testing (Giraldo et al., 2008). Ovarian hormones have been found to affect the amount of intrusive emotional memories experienced by women with PTSD (Feree, Kamat, & Cahill, 2011) and while endogenous estrogen and progesterone were measured as part of the saliva analysis, it is beyond the scope of this study to analyse and discuss these variables, but it is important to note that they may have had an effect on the results of the current study.

Conclusion

This study examined attentional bias to threat in trauma-exposed and non-trauma-exposed individuals before and after acute stress using measures of reaction time, ERP amplitude, and endogenous noradrenaline levels. P3 amplitudes were significantly increased in the trauma-exposed group to congruent trials of the dot probe task, in the post-stress condition. This finding confirms the prediction of a greater attentional bias to threat in the trauma-exposed group using the measurement of P3 ERP amplitude, suggesting a larger recruitment of attentional resources occurs upon presentation of a threatening stimulus to trauma-exposed individuals following a stress induction. However, predictions regarding reaction time, N1 and P1 ERP amplitudes in relation to attentional bias, and a larger noradrenaline increase post-stress in the trauma-exposed group were not confirmed. Conclusions regarding attentional bias cannot be drawn from this study as there was no reliable condition or attentional bias effects, which may have related to an unexpected lack of valence and arousal effects for threat stimuli, and/or lengthy stimulus duration. To further explore the phenomenon of attentional bias to threat in trauma-exposed populations using a dot-probe task, varying stimulus durations should be presented along with more negatively-valenced images, to allow the opportunity to detect attentional bias in non-clinical populations.

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Table of Appendices

Appendix A

Attentional Bias to Threat: ERP, reaction time, and noradrenaline measures.

Participant Information Sheet

1. Invitation

Thank you for your interest in this research. This study is being conducted in partial fulfilment of a Psychology Honours degree for Lauren Reading and Emma Jackson under the supervision of Professor Kim Felmingham, Dr Andrea Carr, and Dr Allison Matthews at the University of Tasmania. Please take your time to read this information sheet to gain a better understanding of the research task and what it will involve. Before you decide to participate, it is important that you understand all of the information below. If you have any further questions or would like more information please contact the researchers at lreading@utas.edu.au (Lauren Reading) or emmaj4@utas.edu.au (Emma Jackson).

2. What is the purpose of this study?

The study aims to assess attentional biases to threat at before and after inducing an acute stress task in individuals who have been exposed to trauma compared to individuals without trauma exposure. The results from this study will be used to inform further research in the area of trauma exposure and PTSD.

3. What will I be asked to do?

As a participant you will be asked to complete a dot-probe task on a computer, where neutral and threatening images will be presented and your reaction time to a dot

appearing on screen after each pair of images will be used to assess attentional bias. You will be required to wear an EEG cap so that your brainwaves can be recorded to further assess your attentional bias and response.

You will be required to undergo a cold-pressor stress task, where you will need to immerse one of your hands into a bucket of water maintained below 4 degrees Celsius for a maximum of three minutes. This may be uncomfortable but will not cause injury and is intended to cause a stress response in the body. You will be also required to give a saliva sample before the dot-probe begins and then after the cold-pressor stress task, to enable measurement of the stress hormone noradrenaline in your system.

4. Are there any possible benefits from participation in this study?

Your participation will promote further research, providing valuable information to clinicians and researchers working with a variety of clients.

5. Are there any possible risks from participation in this study?

This study involves no more than minimal risk (i.e. risks encountered in daily life) and no specific risk is anticipated with taking part in this study. The cold-pressor stress task may be uncomfortable but will not cause injury, and there is a slight risk of skin irritation from the products used to prepare your skin for the placement of the EEG cap. No deception is involved in this study. At any time should you feel uncomfortable or upset completing the tasks involved, please stop the task and approach the researcher.

6. What if I change my mind during or after the study?

Your involvement in the study is completely voluntary and you are able to withdraw at any time without negative consequence. However, please note that after you have completed your testing we will not be able to remove your data from the data-set as there is no way of knowing which responses belong to you, as the data is de-identified.

7. Anonymity

As mentioned above, all data recorded in this experiment will be de-identified, meaning that there is no way to identify who has participated or link any information or scores back to a participant. Participants are assigned a number and their data is stored under that, there is no link between their identity and this number, it is purely a way to separate different participants' information.

8. What will happen to the information when this study is over?

The data relating to the study will be encrypted and stored in a secure, password-protected electronic database on the University of Tasmania, School of Medicine (Psychology) premises. Your name will not be recorded or associated with any experimental data.

The research data will be stored for the minimum of five years. After five years from the date of the first publication all data will be deleted within the formal guideline of the University of Tasmania' data destruction processes.

9. How will the results of the study be published?

The findings of this study will be available at the University of Tasmania website http://www.utas.edu.au/psychology/ or can be requested via email. For further information please contact Lauren Reading at email lreading@utas.edu.au or Emma Jackson at email emmaj4@utas.edu.au. The results will be published as a thesis by both researchers, and may possibly be published by a scientific journal if important findings are made.

10. What if I have questions about this study?

If you have any further questions about this study, please contact Lauren Reading (student researcher) at lreading@utas.edu.au or Emma Jackson (student researcher) at emmaj4@utas.edu.au or Kim Felmingham (Chief Investigator) at Kim.Felmingham@utas.edu.au.

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on +61 3 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H0012494.

Thank you for your time taken reading this information sheet.

Appendix B

Consent form for experimental participants

Attentional bias to threat: ERP, reaction time, and noradrenaline measures

1. I agree to take part in the research study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. I understand that the study involves viewing images which may be threatening in nature, immersing my hand in ice-water for up to three minutes, and giving two saliva samples that will be used only to assess the level of the hormone noradrenaline present in my body. I understand that completion of participation in this study will take approximately two hours of my time.
5. I understand that participation involves the risk(s) that I may be upset by the threatening images presented. If this occurs, I understand that the researcher can refer me to the University Psychology Clinic for counselling.
6. I understand that all research data will be securely stored on the University of Tasmania's premises for five years from the publication of the study results, and will then be securely destroyed.
7. Any questions that I have asked have been answered to my satisfaction.
8. I understand that the researcher(s) will maintain confidentiality and that any information I supply to the researcher(s) will be used only for the purposes of the research.
9. I understand that the results of the study will be published in a manner so that I cannot be identified as a participant.
10. I understand that my participation is voluntary and that I may withdraw at any time without any effect. I understand that I will not be able to withdraw my data after completion as the data has been de-identified and cannot be linked back to me.

Participant's name:

_____

Participant's signature: _____

Date: _____

Statement by Investigator

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Investigator's name:

_____

Investigator's signature:

_____

Date: _____

Appendix C

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 2763
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Human.ethics@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

13 April 2015

Assoc Prof Kim Felmingham
Psychology
Private Bag 30

Sent via email

Dear Assoc Prof Felmingham

Re: APPROVAL FOR AMENDMENT TO CURRENT PROJECT
Ethics Ref: **H0012494 - Trait Social Anxiety and Emotional Processing: An ERP Study**

- Change to student investigators: addition of Lauren Reading and Emma Jackson, removal of Laura Stewart.
- Addition of investigator Dr Allison Matthews.
- Extend data collection to both male and female participants.
- Change of task to use emotional stimuli from the International Affective Picture Series.
- Additional brief self-report measure of previous traumatic life experiences, the Traumatic Life Events Questionnaire.
- Revised Information Sheet.

We are pleased to advise that the Chair of the Tasmania Social Sciences Human Research Ethics Committee approved the Amendment to the above project on 9/4/2015.

Yours sincerely

Appendix D

Attentional Bias to Threat: ERP, reaction time, and noradrenaline measures: Demographic & clinical data

Date: / / Time:

Participant assigned number:

Age: Sex:

Current medications, including contraceptive pill or other forms of hormonal contraceptive (i.e. Implanon, Nuva Ring, Mirena):

Any previously or currently diagnosed psychological or medical disorders (including traumatic or acquired brain injury, learning difficulties, or attentional deficits etc.):

TEQ Score: PCL-5 Score:

DASS-21: Total Score: D: A: S:

Assigned group: TE / NTE

Handedness:

Time spent immersed in cold pressor task:

Appendix E

TRAUMATIC EXPERIENCE

Below is a list of very traumatic or upsetting events that sometimes happen to people. Please indicate if any of these events have happened to you:

1. Have you ever had direct combat experience in a war? Yes □
2. Have you ever been involved in a life-threatening accident? Yes □
3. Have you ever been involved in a fire, flood or other natural disaster? Yes □
4. Have you ever witnessed someone being badly injured or killed? Yes □
5. Have you ever been seriously attacked, assaulted or molested? Yes □
6. Have you ever been threatened with a weapon, held captive, or kidnapped? Yes □
7. Have you ever been tortured or the victim of terrorists? Yes □
8. Have you ever experienced an extremely stressful or upsetting event? Yes □
9. Have you ever suffered a great shock because one of the events on the list happened to someone close to you? Yes □

If you are happy to be contacted for potential participation in a research study related to this questionnaire, please write your contact details below:

Name:_____

Email: _____

Mobile: _____

Appendix F

DASS21

Name: *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (eg, in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3
17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

Appendix G

PCL-5

Instructions: Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then circle one of the numbers to the right to indicate how much you have been bothered by that problem in the past month.

In the past month, how much were you bothered by:	*Not at all*	*A little bit*	*Moderately*	*Quite a bit*	*Extremely*
1. Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2. Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3. Suddenly feeling or acting as if the stressful experience were actually happening again *(as if you were actually back there reliving it)*?	0	1	2	3	4
4. Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5. Having strong physical reactions when something reminded you of the stressful experience *(for example, heart pounding, trouble breathing, sweating)*?	0	1	2	3	4
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7. Avoiding external reminders of the stressful experience *(for example, people, places, conversations, activities, objects, or situations)*?	0	1	2	3	4
8. Trouble remembering important parts of the stressful experience?	0	1	2	3	4
9. Having strong negative beliefs about yourself, other people, or the world *(for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)*?	0	1	2	3	4
10. Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame?	0	1	2	3	4
12. Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13. Feeling distant or cut off from other people?	0	1	2	3	4
14. Trouble experiencing positive feelings *(for example, being unable to feel happiness or have loving feelings for people close to you)*?	0	1	2	3	4
15. Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16. Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17. Being "superalert" or watchful or on guard?	0	1	2	3	4
18. Feeling jumpy or easily startled?	0	1	2	3	4
19. Having difficulty concentrating?	0	1	2	3	4
20. Trouble falling or staying asleep?	0	1	2	3	4

PCL-5 (8/14/2013) Weathers, Litz, Keane, Palmieri, Marx, & Schnurr -- National Center for PTSD

Appendix H

Instructions for dot-probe task

- Please sit comfortably upright, with your face 50cm from the screen of the computer. The experimenter will help you place your chair correctly.
- Place your hands on the keyboard, with your index fingers on the A and L keys. **Pressing A indicates left, pressing L indicates right**.
- For each trial, a pair of images will be presented for 1 second. Please look at the images.
- The images will disappear and be replaced by a white dot on the left or right.
- You will need to press the key that corresponds to the same side of the screen as the dot as fast as you can once you see the dot.

  Again, **the A key indicates left, the L key indicates right**
- The next set of images will appear once you have done this, with 57 trials in total, taking approximately 7.5 minutes to complete.
- **Please keep as still as possible, breathe and blink normally, and do not worry about any mistakes you may make, just be ready for the next trial when it appears.**
- **If you have any questions, please ask the experimenters**.

Thank you again for your participation.

Appendix I

Table 2. Non-significant interaction effects in dot-probe reaction time data

Variables	*df*	*F*	*p*	η^2_ρ	λ
Condition x Group	2, 34	1.516	.234	.082	.918
Condition x Time	2, 34	1.494	.239	.081	.919
Time x Group	1, 35	.379	.542	.011	.989
Condition x Time x Group	2, 34	2.030	.147	.107	.893

Appendix J

Table 3. Non-significant interaction effects for P1 ERP component

Variables	*df*	*F*	*p*	η^2_p	λ
Condition x Group	2, 34	.649	.529	.037	.963
Time x Group	1, 35	.039	.845	.001	.999
Cond x Time	2, 34	.678	.514	.038	.962
Site x Group	2, 34	.428	.655	.025	.975
Site x Cond	4, 32	.977	.434	.109	.891
Site x Time	2, 34	1.011	.374	.056	.944
Cond x Time x Group	2, 34	2.035	.146	.107	.893
Cond x Site x Group	4, 32	.820	.522	.093	.907
Time x Site x Group	2, 34	.341	.713	.020	.980
Cond x Time x Site	4, 32	.737	.574	.084	.916
Cond x Time x Site x Group	4, 32	.885	.484	.100	.900

Appendix K

Table 4. Non-significant interactions for N1 ERP component

Variables	*df*	*F*	*p*	η^2_ρ	λ
Condition x Group	2, 34	1.411	.258	.077	.923
Time x Group	1, 35	.943	.338	.026	.974
Cond x Time	2, 34	2.722	.08	.138	.862
Site x Group	1, 35	.498	.485	.014	.986
Site x Cond	4, 32	.227	.798	.013	.987
Site x Time	1, 35	.022	.883	.001	.999
Cond x Time x Group	2, 34	.459	.636	.026	.974
Cond x Site x Group	4, 32	.513	.603	.029	.971
Time x Site x Group	1, 35	.821	.371	.023	.977
Cond x Time x Site	2, 34	.044	.957	.003	.997
Cond x Time x Site x Group	2, 34	.928	.405	.052	.948

Appendix L

Table 5. Non-significant interactions for P3 ERP component

Variables	*df*	*F*	*p*	η^2_ρ	λ
Condition x Group	2, 34	.381	.686	.022	.978
Time x Group	1, 35	.186	.669	.005	.995
Cond x Time	2, 34	.674	.516	.038	.962
Site x Group	2, 34	.185	.832	.011	.989
Site x Cond	4, 32	.245	.066	.234	.766
Site x Time	2, 34	.1484	.241	.080	.920
Cond x Site x Group	4, 32	1.963	.124	.197	.803
Time x Site x Group	2, 34	.124	.884	.007	.993
Cond x Time x Site	4, 32	.504	.733	.059	.941
Cond x Time x Site x Group	4, 32	.663	.623	.076	.924

Appendix M

Table 6. Means and standard deviations of valence and arousal ratings of neutral and negative images by TE and NTE group in picture rating task.

	Valence	Arousal
TE negative	4.68 (.38)	3.21 (1.04)
TE neutral	4.68 (.38)	3.07 (1.20)
NTE negative	5.01 (.89)	2.90 (1.04)
NTE neutral	4.79 (.91)	2.92 (1.08)

Appendix N

Table 7. Non-significant main effects and interactions for picture rating task.

	df	*F*	*p*	η^2_ρ	λ
Arousal					
Image	1, 28	.690	.413	.024	.976
Group	1, 28	.356	.555	.013	
Image x Group	1, 28	1.15	.293	.039	.961
Valence					
Image	1, 28	3.31	.080	.106	.894
Group	1, 28	.818	.373	.028	
Image x Group	1, 28	3.79	.062	.119	.881

Appendix O

Table 8. Post-analysis literature review of dot-probe stimulus duration

Authors, year	*n*	Stimulus duration (ms)	Number of trials	Attentional bias found	Other finding
Bar-Haim et al., 2010	131	1000	152	No	Avoidance
Dalgleish et al., 2001	24	1500	196	Yes	
DePierro et al., 2013	27	1000	53	Yes	
Elsesser et al., 2004	86	500	44	No	Avoidance
Fani et al., 2011	161	500	80	Yes	
Fani et al., 2012	64	500	80	Yes	
Kappenman et al., 2014	96	500	360	No	ERP att. bias
Koster et al., 2004	44	500	80	Yes	
Li, Li, & Luo 2005	30	600	640	Yes	
McHugh et al., 2010 (1)	35	500	192	No	Avoidance
McHugh et al., 2010 (2)	65	500	192	Yes	
Naim et al., 2015	415	1000	100	Yes	
Price et al., 2015 (1)	29	500	3840	Yes	
Price et al., 2015 (2)	15	500	1280	Yes	
Price et al., 2015 (3)	28	2000	240	Yes	
Salum et al., 2012 (1)	1774	1250	192	No	Avoidance
Salum et al., 2012 (2)	1774	500	192	Yes	
Waechter et al., 2015	89	500	256	Yes	
Waters et al., 2004	175	1250	180	Yes	
Zhang et al., 2014	26	500	140	Yes	